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MEASUREMENT OF NO_2 INDOOR AND OUTDOOR CONCENTRATIONS IN SELECTED PUBLIC SCHOOLS OF LAHORE USING PASSIVE SAMPLER

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ABSTRACT

Higher levels of NO_2 are a danger to human health especially for children. A seven day study was carried to find out the ambient concentrations of NO_2 in 27 schools of Lahore with the help of passive samplers. In each school three sites were selected, viz: laboratory, corridor and outdoors. After 7 days exposure the tubes were subjected to spectrophotometric analysis. Results showed that the maximum values measured in laboratory, outdoor and corridors were 376µg/m^3, 222µg/m^3 and 77µg/m^3. Minimum values for laboratory, outdoor and corridors were 10µg/m^3, 20µg/m^3 and 8µg/m^3. Factors affecting these values were laboratory activities and proximity to main roads. These values were significantly higher than the standard values defined by EPA. Therefore children in schools were at risk of developing health complications.

Key Words: Nitrogen dioxide, Lahore, passive samplers, schools, spectrophotometric analysis

INTRODUCTION

Pollution in developing countries, particularly, in urban centres is a major public health issue due to rapidly growing population, urbanization, automobile numbers and heavy industry. Consequently urban populations are facing serious health implications such as pneumonia, lung cancer and acute lower respiratory infections especially for women and children (Bruce *et al*., 2006). Children are more susceptible to diseases as they spend more time with their mothers in homes, on roads playing and in schools which are situated in areas with excessive levels of various air pollutants (Sapkota *et al*. 2008) and because of their higher physical activities and breathing rates (Trasande and Thurston, 2005). Animal studies showed that outdoor air pollution might cause inflammation of the central nervous system which can affect the conduct and performance of school going children (Michelle*et al*. 2012). Ambient air pollution is linked to 3.7 million premature deaths and most of these (88%) were in low and middle income countries (WHO 2014).

Air quality in Pakistan is a serious issue to address and it is continuously deteriorating. A major source of air pollution in Pakistan is emissions from automobiles and motor vehicles. Other sources include coal burning, industry and household fuel combustion for domestic use (Ilyas *et al*. 2008). In Pakistan since 2001 – 02 the number of vehicles has grown by 130.3% (Pakistan Economic Survey, 2013-2014). NO_2 is second hazardous pollutant in Pakistan after particulate matter and its reported levels were much higher than the international standards of WHO (Colbeck*et al*. 2010).

A study was conducted by Pak EPA in five major cities (Karachi, Lahore, Quetta, Peshawar, and Islamabad) to record the concentration of NO_2. Among these cities, the highest average concentration of 76µg/m_3 was found in Karachi and Lahore followed by Quetta (69µg/m^3), Peshawar (47µg/m^3) and Islamabad (30µg/m^3) (Pak-EPA/JICA 2006). Another study in Murree was carried out at 15 different locations of schools and roads. The highest concentrations were recorded on the Mall Road (76.9µg/m^3) and Ghora Gali (74.4µg/m^3) whereas the lower concentration of 5.1µg/m^3 was recorded at the High School (Pak-EPA 2006).

A recent study was conducted to evaluate the concentrations of pollutants in Gulberg II, Lahore. Among these pollutants the 220µg/m^3 of NO_2 was recorded which was significantly higher than the NAAQS permissible limit (80µg/m^3) (Abrar *et al*. 2014). These higher NO_2 levels in urban centres of Pakistan are a serious threat to public health especially children and elderly. Children spend a significant amount of their time in schools and the state of air quality in educational built environments in urban centres is likely to be influenced by ambient air quality. Poor air quality inside the schools may have significant health impacts on children. In China a study conducted in 10 schools of Taiyuan, showed the elevated levels of indoor concentration of NO_2 (39.4 µg/m^3) and outdoor levels were two to three fold higher. Students showed the symptoms of cumulative asthma, wheezing and daytime attacks of breathlessness (Zhao *et al*. 2008).

With reference to Pakistan very limited data is available on levels of NO_2 in schools. Hence the current study was carried out to evaluate levels of NO_2 in

different schools across Lahore. The findings will offer insights into the degree of child exposure to NO_2 at urban schools.

MATERIALS AND METHODS

Sampling Site: Lahore is the most populous city in Punjab Province, Pakistan covering a total area of 1772 km^2.It is located between 31°15′ and 31°45′ N and 74°01′ and 74°39′ E. Under the administrative government, Lahore is divided into different areas called as towns.

Fig. 1. Map of Lahore, black dots indicates the location of schools (source; Google maps)

Sampling Design: Twenty seven schools in nine towns (three schools in each town) of Lahore city were selected as sampling sites. The Schools were selected on the basis of floor area (Figure 1 and Table 1). The three selected sampling points in each school were laboratory, ambient and corridor as a semi-ambient sampling site. Sampling tubes were exposed for seven days.

Preparation of Passive Samplers: The passive samplers were prepared by cleaning the tube components with suitable detergent followed by rinsing with tap water. The final rinse was done with deionized water .The tube components were air dried. Grids were dipped in 50% TEA/acetone solution and stirred with glass rod for five minutes. Grids were removed using clean forceps, placed on blotting paper, followed by the assembly of grids (two grids per tube) into a dark coloured tube cap. A white cap was placed on the other tube end.

Exposure of Passive Samplers: The tubes were exposed, dark coloured cap upper most and white cap removed, at a height of two meters above the floor for one week. At the end of the period the white cap was replaced.

Spectrophotometric Analysis: After sample collection, the passive samplers were analysed by the spectrophotometer. The colour reagents were prepared by mixing sulphanilamide in orthophosphoric acid and naphthyle ethylene diamine dihydrochloride (NEDD).The spectrophotometer was calibrated using standard solutions. The concentration of nitrite reacted with the TEA-coated grids was extracted by adding 3ml of colour reagent and absorbance was measured at 542 nm.

Data Analysis: The calculations for mean, minimum and maximum along with standard deviation for one week in each setting were made. Aone-way ANOVA was carried

out to compare the difference in the NO_2 concentration at the three points in all schools. Statistical analysis was carried out with SPSS (version 20).

Table 1. Details of selected schools, their relevant towns, area, and number of students and surroundings

Town	School ID	Area (ft^2)	No. Of students	Surrounding details
Aziz Bhatti Town	I	45000	605	Populated area, less traffic less greenery
	II	112,500	1566	Populated area, near main busy road
	III	162,000	694	Populated area, less traffic less greenery
Data Gunjbaksh Town	I	36000	682	Dense population, near main busy road, no greenery
	II	67000	536	Dense population, near main busy road and petrol pump, no greenery
	III	139,500	778	Dense population, near main busy road, no greenery
Gulberg Town	I	40500	639	Dense population, near main busy road and petrol pump, no greenery
	II	81000	520	Residential area, greenery present, near filling station
	III	351,000	1249	Dense population, near main busy road, no greenery, near canal
Allama Iqbal Town	I	4500	322	Dense population, near main busy road, no greenery
	II	81000	368	Dense population, near main busy road, no greenery
	III	225,000	1529	Dense population, near main busy road, no greenery, construction site nearby
Nishter Town	I	9000	987	Dense population, near main busy road, no greenery
	II	63000	791	Dense population, near main busy road, no greenery
	III	130,500	728	Dense population, near main busy road, no greenery
Ravi Town	I	18000	1018	Dense population, no greenery
	II	85500	1746	Dense population, no greenery
	III	211,500	1648	Dense population, no greenery, main road and railway track nearby
Samanabad Town	I	4500	316	Residential area, high population
	II	67500	744	Dense population, no greenery, main road nearby
	III	247,500	2873	Dense population, no greenery, main road and food market nearby
Shalimar Town	I	9000	289	Dense population, no greenery, main road and railway workshop nearby
	II	63000	1390	Dense population, no greenery, main road and canal nearby
	III	216,000	2665	Dense population, no greenery, main road nearby, heavy traffic,
Wahga Town	I	18000	840	Dense population, greenery
	II	72000	436	Less populated area, greenery and fields, brick kiln
	III	175,500	1361	Heavy traffic, populated area

RESULTS AND DISCUSSION

The Table 2 summarizes the weekly mean, minimum and maximum values along with standard deviation at three sampling points in all the selected schools located in different towns.

The maximum NO_2 values at Laboratory, Outdoor and Corridor were found to be 376µg/m³, 222µg/m³.and 78µg/m³respectively .The minimum observed values for the same treatments were 10µg/m³, 20µg/m³and 8µg/m³ (Fig.2).

The weekly average NO_2 concentration in the corridor, laboratory and outdoor in Shalimar town were measured to be 51.3µg/m^3, 39.3µg/$m^3$and 55.3µg/m^3respectively. The heightened outdoor value is due to the location of school on nearby main road with continuous traffic flow and insignificant vegetation. The average concentrations in the schools of Data Gunjbaksh Town were 69.3µg/m^3in corridor, 54.3µg/m^3 in laboratory and 70µg/m^3in outdoor. All the schools in this town were located in a densely populated area and on the main road. School 1 was adjacent to a gas filling station. The considerable higher value in the laboratory highlights probable contribution from performing laboratory experiments as well outdoor sources. The average concentration of NO_2 in Aziz Bhati Town (corridor: 41.7µg/m^3, laboratory: 19µg/$m^3$and outdoor: 42.3µg/m^3) is remarkably less than that of the above mentioned towns. The difference

might be due to the demography, vegetation and spacious buildings of schools without a sufficient natural ventilation system.

In Gulberg Town, lower levels ofNO_2 in the laboratory (29.3µg/m^3) than corridor (52.7µg/m^3) and outdoor (58.3µg/m^3) indicates a fewer laboratory activities and less usage of nitrogen based chemicals. Schools II and III were located near to the main road and filing stations that significantly contributed to NO_2 outdoors and in the corridor. In Allama Iqbal Town schools II and II were located in populated areas with high density traffic. Average concentrations in the corridor and outdoor were equal (58.7µg/m^3). Windows to the laboratory tended to be open resulted in outside NO_2 entry (33µg/m^3). All three schools in Nishter Town were located near the Kot Lakhpat industrial area, having intense traffic density. The increased NO_2 levels were observed in corridor, laboratory and outdoor as high as 60µg/m^3, 41µg/m^3 and 87µg/m^3 respectively.

Table 2. Mean, maximum and minimum and standard deviation values of NO_2 (µg/m^3) in nine towns

Towns	Laboratory				Corridor				Outdoors			
	Mean	Max	Min	SD	Mean	Max	Min	SD	Mean	Max	Min	SD
Shalimar Town	39.3	50	31	9.7	51.3	63	38	12.6	55.3	60	50	5.0
Data Gunjbaksh Town	54.3	60	47	6.7	69.3	78	62	8.1	70.0	77	65	6.2
Aziz Bhatti Town	19.0	26	15	6.1	41.7	47	36	5.5	42.3	46	39	3.5
Gulberg Town	29.3	39	23	8.5	52.7	55	50	2.5	58.3	61	55	3.1
Allama Iqbal Town	33.0	42	27	7.9	58.7	64	55	4.4	58.7	70	53	9.8
Nishter Town	41.0	43	39	2.0	60.0	66	56	5.3	80.3	87	74	6.5
Ravi Town	28.0	51	10	21.0	34.7	43	29	7.8	45.3	52	37	7.6
Samanabad Town	53.0	68	42	13.5	57.7	75	45	15.5	120.0	222	62	88.6
Wahga Town	136.7	376	11	207.4	31.3	59	8	25.8	28.3	39	20	9.7

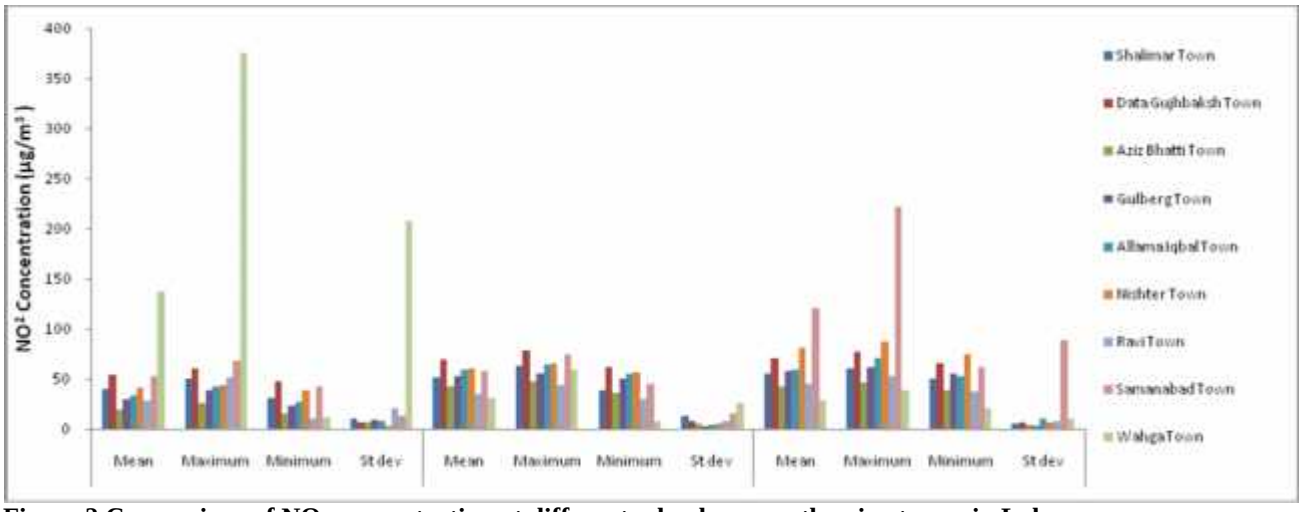

Figure 2 Comparison of NO_2 concentration at different schools across the nine towns in Lahore

In the Ravi Town, schools II and III were located near a railway track and a smaller road respectively. This caused a significant increase in the average outdoor (45.3µg/m^3) as well as corridor values (34.7µg/m^3). The lesser use of laboratory of schools is perhaps the main reason of low values of NO_2 (28µg/m^3). The highest mean outdoor value (120µg/m^3) was observed in Samanabad Town. The key factors were the presence of a number of small open air restaurants and marriage halls in close proximity of the schools. The installation of a small recycling plant in school II and usage of LPG stove in the laboratory of school III

contributed to the laboratory values (53 µg/m^3) of NO_2. In Wahga town schools II and III were located in the semi-rural areas with green fields and less traffic. Although trucks are used for trading purposes between Pakistan and India they are still some distance from the schools. The highest level of NO_2 in the laboratory of school II was due to the usage of LPG stove.

Comparison with other studies: Colbeck *et al* (2010) measured the weekly concentrations at the rural and urban sites in winter and summer in Pakistan and observed levels ranging from 64µg/m³ to 699µg/m³.Another study conducted by Zafar *et al*., (2012) observed the maximum ambient levels of NO_2 to be 19 µg/m³ in heavy traffic areas while the lowest concentration was 7.61µg/m³. The concentration was very high as compared to our one week study. Factors like season, burning of fossil fuels and environmental pollution raised the NO_2 level. Adon *et al.* (2010) conducted a study to determine the long-term concentrations (1998 to 2007) of SO_2, NO_2, HNO_3, NH_3 and O_3, by using passive samplers at seven distant sites in West and Central Africa. Annual mean NO_2 concentrations varied from 1.7µg/m^3 in forests to 4.5µg/m^3 in the dry savannas. In our study the high concentration was due to the biomass combustion in cities. Rojas-Brachoand *et al*. (2002) conducted an exposure study on the children living in Santiago, Chile. Concentrations of NO_2 were measured during the winter of 1998 and 1999. Indoor and outdoor NO_2 concentrations were comparable 67.3µg/m^3 and 69.4µg/m^3 and higher than personal exposures (48.6µg/m^3). Kulkarni and Patil (1998) conducted a two day study to determine the personal exposures to NO_2 during the winter and summer. Personal exposures were found to differ among the 43 respondents, ranging from 19 to 164.5µg/m^3 with a mean of 82µg/m^3 in winter and 44µg/m^3 in summer. The concentration was very high as compared to our study. The factors like congested houses, season of the year, burning of fossil fuels and environmental pollution raised the NO_2 level.

Conclusions: The following conclusions can be drawn from the present study:

i. Higher outdoor values resulted from the usage of the fossil fuels, heavy traffic, usage of construction equipment and less vegetation around the schools.
ii. Higher levels in the laboratory indicated the work of students in the laboratories, improper, sealing, packing and placement without proper ventilation system.
iii. Although, the exposure time is one week, it is expected that concentration would probably surpass the annual values (40ug/m^3) of the WHO guideline.
iv. The present study has been carried out in one large city (in nine towns) having its own definite geography, industrialization, vegetation, fuel use pattern, urban planning and emission control strategies. These features may cause variations in concentration across the country.

The air quality, in most of the schools, is deteriorating. Therefore, children in schools are at risk of developing health complications. PAK-EPA should take precautionary steps to reduce the level of NO_2.Many financial institutions launched the liberal leasing system that heightened the traffic density to an alarming stage. Although road infrastructures are improving there is a dire need to manage the traffic flow, particularly, in vicinity of schools. Also the School Education Department should take serious considerations about the location of schools for the better health of the children.

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